Mapping Phytoplankton Community Composition in Lake Erie Surface Waters (IFYLE 2005)

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INTRODUCTION

Phytoplanktonic organisms are important to the structure and function of lake ecosystems. In Lake Erie, phytoplankton abundance has diminished due to nutrient control efforts in the 1970s and the arrival of the dreissenid mussels in the late 1980s. Phytoplankton composition, however, has varied over the decades (Makarewicz 1993).

We used the FluoroProbe (bbe-Moldanke) and a geographic information system (GIS) to conduct fine scale spatial mapping of phytoplankton community composition in Lake Erie surface waters June 8-12, July 11-15, and September 7-11, 2005.

METHODS

During three cruises on Lake Erie water was pumped from a depth of approximately 1.5 m into a continuous flow through unit (ferry box, volume = 9.5 L), in which was submersed the FluoroProbe. Water temperature, total Chlorophyll-a (Chl-a), and the proportion of major algal divisions, i.e. Chlorophyta, Cyanobacteria, Heterokontophyta & Dinophyta, Cryptophyta (µg Chl-a/L equivalents) were measured every 3-30 seconds. Ship velocity was 8-11 knots.

The FluoroProbe's internal clock was synchronized with the time stamped differential GPS ship log, so that all data could be georeferenced. The flow rate through the ferry box was calibrated to obtain a resolution of 0.5 km of linear distance traveled over the lake surface.

Data were entered into ArcGIS™. Using ArcMap, the concentrations of the algal divisions were shown with graduated colors to represent ranges of values along transects (Fig. 1, Fig. 2). The natural breaks (jenks) classification method was used to determine theses ranges. ArcGIS™ Spatial Analyst was used to interpolate point data along transects to raster images using kriging to estimate total Chl-a and Cyanobacteria concentrations beyond the extent of the transects (Fig. 3, Fig. 4). To estimate the confidence in these estimates, variance of prediction raster images were produced (Fig. 5).

Total Chl-a in Lake Erie (1.5 m depth) Along Transects September 7-11, 2005

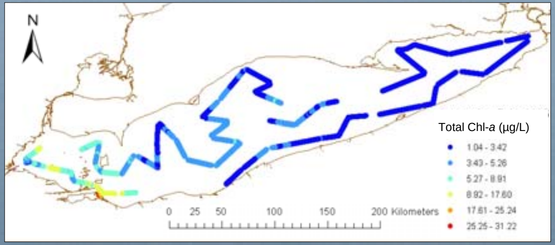

Figure 1. Concentration of chlorophyll-a along transects in Lake Erie September 7-11, 2005. Water was sampled from a depth of 1.5 m while underway onboard the R/V *Lake Guardian*. Data were entered into ArcGIS™. Total Chl-a is represented by graduated colors that display ranges of values based on natural breaks in the data.

RESULTS

Total Chl-a increased lakewide from June to July to September. Concentrations were highest in the western basin and lower in the central basin and eastern basin.

In **June** total Chl-a was low along transects in the eastern basin (0.1-0.5 µg/L in the south and 0.5-1.0 µg/L in the north). Along transects in the central basin most values ranged from 0.1-0.5 µg/L, but some locations ranged from 1.0-1.5 µg/L. Along transects in the southern part of the central basin values ranged from 0.5-2.6 µg/L. Total Chl-a was variable along transects in the western basin, with values ranging from 0.1-4.7 µg/L.

In **July** total Chl-a was less than 1.3 µg/L along transects in the eastern and central basin. In the western basin, from Sandusky Bay to Toledo, and north towards Monroe, total Chl-a was higher. Most locations sampled along these transects ranged from 3.1-6.3 µg/L. Near Sandusky Bay, values ranged from 6.3-10.9 µg/L, and near station 496 values ranged from 10.9-18.3 µg/L. Almost all values recorded near Toledo ranged from 10.9-18.3 µg/L.

In **September** total Chl-a was relatively low along transects in the eastern basin (1.0-3.4 µg/L). Along transects in the central basin, concentrations ranged from 1.0-3.4 µg/L and 3.4-5.3 µg/L. In the western basin total Chl-a ranged from 5.3-17.6 µg/L along most transects. As in July, eutrophic conditions were detected near Sandusky Bay with concentrations ranging from 25.3-31.2 µg/L.

Cyanobacteria (1.5 m depth) in the Western Basin of Lake Erie July 12-13, 2005

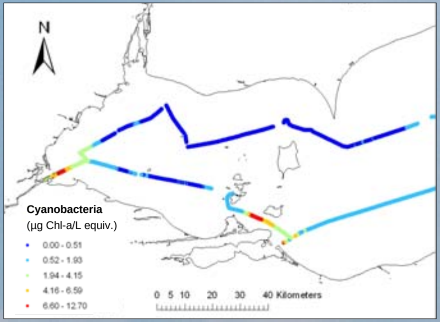

Figure 2. Concentration of Cyanobacteria in the western basin of Lake Erie July 12-13, 2005. Water was sampled from a depth of 1.5 m while underway onboard the C.C.G.S. *Limnos*. Data were entered into ArcGIS™. Graduated colors represent ranges of cyanobacteria concentration based on natural breaks in the data.

Cyanbobacteria in the Western Basin of Lake Erie July 12-13, 2005

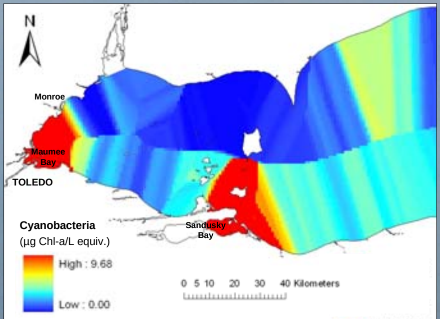

Figure 3. Concentration of Cyanobacteria in the western basin of Lake Erie July 12-13, 2005. Water was sampled from a depth of 1.5 m while underway onboard the C.C.G.S. *Limnos*. Data were entered into ArcGIS™ and kriging was used to estimate concentration. Cyanobacteria concentration is high in and surrounding Sansusky and Maumee Bays, and south of Monroe, MI.

Total Chl-a in Lake Erie (1.5 m depth) September 7-11, 2005

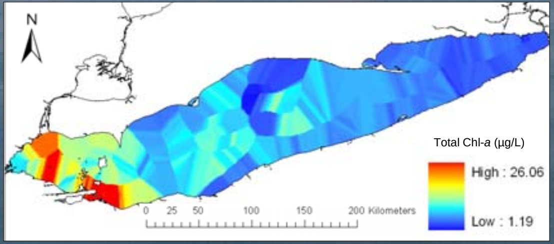

Figure 4. Concentration of chlorophyll-a in Lake Erie September 7-11, 2005. Water was sampled from a depth of 1.5 m while underway onboard the R/V *Lake Guardian*. Data were entered into ArcGIS™ and kriging was used to estimate concentration. Total Chl-a is represented by a continuous graduated color scale.

Community Composition

Except for Cryptophyta, which was undetectable in July, concentrations of all the major algal divisions increased from June to July to September. Concentrations ranged in value relative to total Chl-a. Heterokontophyta & Dinophyta (diatoms, naked chrysophytes and dinoflagellates) were most abundant, followed by Chlorophyta (green algae), both of which measured highest values along transects in the western basin. Cryptophytes were common, but less abundant, except along transects in the central basin in September, where values ranged from 3.6-5.5 µg/L.

Areas of very high Cyanobacteria (blue-green algae) concentration were encountered in July and September in the western basin. In July, Cyanobacteria concentration ranged from 6.6-12.7 µg/L along transects near Sansusky Bay and in Maumee Bay (Fig. 2). In September, Cyanobacteria concentrations increased near Sandusky Bay. Most values measured near 10 µg/L, however, in locations nearest to Sandusky Bay, values ranged from 18.8-26.5 µg/L.

DISCUSSION

Monitoring water quality is a critical component of conservation and sustainable use of the Great Lakes-St. Lawrence ecosystem. Through the utilization of a GIS and advanced instrumentation, we have produced maps of phytoplankton community composition in Lake Erie.

Cyanobacteria (blue-green algae) require special attention, because blooms can be harmful to humans and cause damage to wildlife, including fish and waterfowl. Humans are exposed to the bacteria by drinking or coming in contact with contaminated water (Falconer 1999).

Error is associated with kriging. Assuming a normal distribution of error, there is a 95% probability that the actual concentration at a given location is the estimated concentration ± two times the square root of the value shown in a variance of prediction raster at that location. However, water currents as well as near-shore/offshore gradients influence phytoplankton composition and biomass, and these factors have not been accounted for in the estimates. Kriging has interpolated concentrations by determining spatial relationships between data points. More accurate *biological* estimates may be obtained by developing methods for interpolation that include *physical* factors such as water currents and shoreline influences.

Variance in Kriging Estimates: September 7-11, 2005

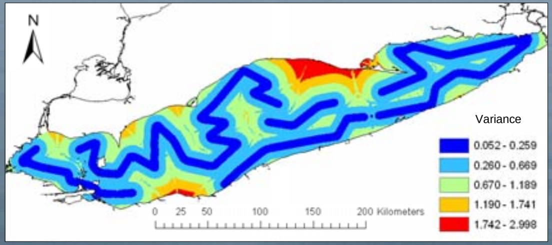

Figure 5. Variance in kriging estimates of concentrations in Lake Erie September 7-11, 2005. Variance is represented by graduated colors that display ranges of values based on natural breaks in the results. Certainty in the interpolations is highest near transects and decreases as distance away from point sampled data increases.

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